

5 **Patent Claims**Method and Circuit Arrangement for Non-destructive Examination
of Objects by Means of Ultrasonic Waves

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1. A method for processing signals which are generated during the non-destructive examination of objects (12, 24), e.g. pipes or sheet metal, by reflection of ultrasonic waves at defect locations (20, AF) of the structure of the object (12, 24), comprising the steps of:

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- emission of a complete wave front onto at least one section of the object (12, 24) to be examined by means of a plurality of independent transmitter elements (EL1 - ELN),
- reception of a wave reflected by the structure of the object by means of a plurality of receiver elements (EL1 - ELN) which are independent of one another,

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- digitalizing the signals received from the receiver elements (EL1 - ELN),
- storage of the digitalized signals according to amplitude and propagation time in a storage element (SP),

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characterized in that

the defect locations (20) are detected by a phase-locked addition of the stored amplitude values along a propagation time.

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2. The method according to claim 1,
characterized in that

5 to identify a defect location (outer defect) (20, AF) on an outer surface (54) of the object (12, 24), the point-wave signals passing from the defect location (20, AF) are evaluated.

10 3. The method according to claim 1 or 2,
characterized in that

15 the defect location (AF) on the outer surface of the object (12, 24), i.e. the surface facing the probe (14, 26, 28), is effected by an addition of those amplitude values stored in the storage module (SP) which are derived from the point-wave signals proceeding from the outer defect (AF).

20 4. The method according to at least one of the preceding claims,

25 characterized in that
the addition extends at a right angle or essentially at a right angle to the interference pattern of the received amplitude values of the point waves of the outer defects (AF).

30 5. The method according to at least one of the preceding claims,
characterized in that

35 the outer defect (AF) takes place by a comparison of the sum signal determined during the phase-locked addition of the stored amplitude values along a propagation time with the sum signal determined during the addition of the amplitude values of the interference pattern, an outer defect (AF) being present if both sum signals indicate a defect location (coincidence method).

5 6. The method according to at least one of the preceding
claims,
characterized in that
the individual transmitter elements (EL1 - ELN) are
controlled in a time-delayed manner (phasing) to set a
beam angle α adapted to the test conditions, e.g. type of
defect, size of defect, type of material, material form.

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7. The method according to at least one of the preceding
claims,
characterized in that
a propagation time dependent amplitude correction of the
sum signal determined during the addition is performed to
identify the location of the defect.

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20 8. The method according to at least one of the preceding
claims,
characterized in that
the received signals are filtered, preferably wavelet
filtered, after their digitalization for the data
reduction.

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9. The method according to at least one of the preceding
claims,
characterized in that
the contour of a surface (68, 70) of the object (12, 24,
66) to be examined is recorded and stored,
the independent transmitter elements (EL1 - ELN) are
controlled in a time-delayed manner in such a way that the
emanating wave front (74) extends parallel or
30 approximately parallel to the contour of the surface (68,
70) of the object (66) and the waves reflected by the
object (66) are received in a time-delayed manner and

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5 generate an essentially planar interference pattern (76).

10. A method for the non-destructive examination of a contour of an object (12, 24, 66) by processing signal waves which are generated by reflection of ultrasonic waves at defect locations (20, AF) of the structure of the object (12, 24), comprising the steps of:

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- emission of a complete wave front onto the at least one contour of the object (12, 24, 66) to be examined by means of a plurality of independent transmitter elements (EL1 - ELN),
- reception a wave reflected by the structure of the object by means of a plurality of receiver elements (EL1 - ELN) which are independent of one another,
- 20 - digitalizing the signals received from the receiver elements (EL1 - ELN),
- storing the digitalized signals according to amplitude and propagation time in a storage element (SP),

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characterized in that

the contour of a surface (68, 70) of the object (12, 24, 66) to be examined is recorded and stored,
30 the independent transmitter elements (EL1 - ELN) are controlled in a time-delayed manner in such a way that the emanating wave front (74) extends parallel or approximately parallel to the contour of the surface (68, 70) of the object (66) and the waves reflected by the object (66) are received in a time-delayed manner and generate a substantially planar interference pattern (76).

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11. The method according to at least one of the preceding

5 claims,
characterized in that
the contour of the object (66) is determined by emitting,
for example, a planar wave front (64) onto the contour to
be examined,

10 the waves reflected by the contour of the object (66) are
received, digitalized by means of the plurality of
receiver elements (EL1 - ELN) which are independent of one
another and the digitalized signals are stored in the
storage element (SP) at least according to propagation
15 time,

the contour of the object is computed from a defined
distance (A) of the probe to the object (66) and the
different propagation times of the received signals.

20 12. The method according to at least one of the preceding
claims,
characterized in that
an interference pattern (76) determined from the received
signals is compared with a desired pattern and that, when
25 there is a deviation from the desired pattern, a renewed
contour measurement is performed.

30 13. The method according to at least one of the preceding
claims,
characterized in that
a subsequent determination of the contour of the object to
be examined takes place during an measuring process.

35 14. The method according to at least one of the preceding
claims,
characterized in that
the wave front (74) extending parallel or essentially

5 parallel to the contour of the object (66) to be examined
is generated by a time-delayed emission of sound pulses.

15. The method according to at least one of the preceding
claims,

10 characterized in that

the received planar interference pattern (76) is received
by time-delayed actuation of the receiver elements (EL1 -
ELN) which are independent of one another in dependence on
the contour values stored in the storage unit.

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16. A circuit arrangement (22) for processing signals which
are generated during the non-destructive examination of
objects, e.g. pipes, sheet metal, by reflection of
ultrasonic waves at defect locations of the structure of
the object, comprising a signal recording unit (38) with a
pulse generator (PE) for actuating transmitter/receiver
elements (EL1 - ELN) for emitting a complete wave front
and for switching the transmitter/receiver elements (EL1 -
EL2) to receive, wherein a multiplexer (MUX) is provided
20 via which analog signals applied to the receiver elements
can be transmitted to A/D converters (AD1 - ADN), the
outputs of which are connected to a storage element (SP)
for storing digitalized signals,
characterized in that

30 the digitalized signals are stored in the storage element
(SP) with respect to their signal amplitude and
propagation time and a summing element (SUM) for the
phase-locked addition of the amplitude values stored in
the storage element (SP) is arranged in tandem behind the
storage element (SP) and a signal which can be evaluated
35 with respect to the defect location (20) is applied to an
output of the summing circuit (SUM).

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17. The circuit arrangement according to claim 16,
characterized in that

the output of the summing element (SUM) is preferably
connected via an interface I with an evaluation circuit
10 (46) in which an output of the summing element (SUM) is
connected with a signal processing circuit (46) which has
one or more evaluation modules (F1, F2) for the further
assessment and evaluation of the signal applied to the
output of the summing element (SUM).

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18. The circuit arrangement according to claim 16 or 17,
characterized in that

the evaluation module (F1, F2) has a coincidence circuit
for comparing the sum signals during a phase-locked
20 addition of the amplitude values along a propagation time
with the sum signals during addition of the amplitude
values of the point-wave signals of outer defects.

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19. The circuit arrangement according to claim 16 to 18,
characterized in that

the probe (14, 26, 28) is configured as a Phased Array
Transducer.

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20. The circuit arrangement according to claim 16 to 19,
characterized in that

the transmitter/receiver elements (EL1 - ELN) can be
controlled simultaneously or in a phase-shifted manner
(phasing).

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21. The circuit arrangement according to claim 16 to 20,
characterized in that

the transmitter/receiver elements (EL1 - ELN) are made as

5 a unit.

22. The circuit arrangement according to claim 16 to 21,
characterized in that

10 the transmitter elements and receiver elements are made
as separate units.